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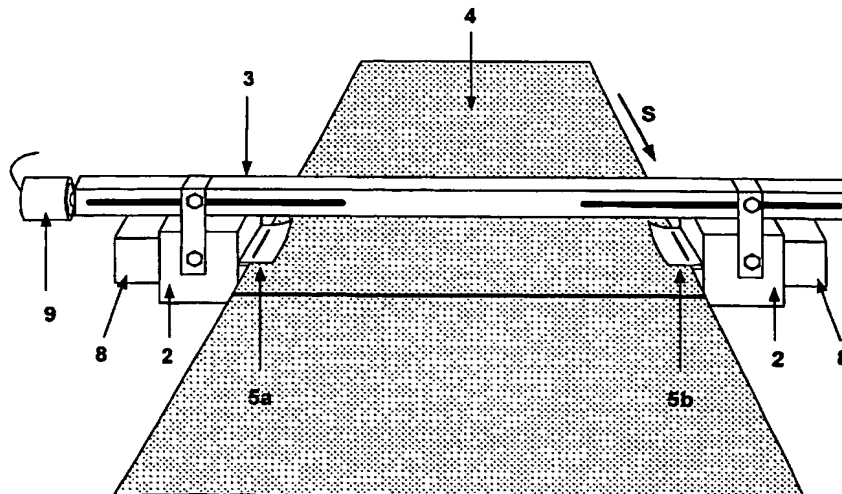
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(54) Title: AN AUTOMATIC CONTROL AND MONITORING SYSTEM FOR SPLICE OVERLAPPING TOLERANCE IN TEX-
TILE PLY

(57) Abstract: The present invention describes a system that enables the monitoring and automatic control of the tolerance in splice overlap of textile ply, through the identification of the overlap area (1a), identification and counting of textile cords (1b) in the referred overlap area, and the generation of a control signal for the remaining manufacturing equipment, based on parameters and criteria defined by the user. The system is composed of: an image acquisition sub-system (2) containing modules of lighting, of artificial vision and respective elements of support, fixation, conditioning and adjustment (3); a quality control computer program constituted by a module of morphologic image analysis for the detection and recognition of the overlap of the ply, detection and counting of cords in the overlap area, a module of support to the decision of acceptance/rejection of the ply based on parameters defined by the user and a module of interface with production equipment.

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DESCRIPTION**AN AUTOMATIC CONTROL AND MONITORING SYSTEM FOR
SPLICE OVERLAPPING TOLERANCE IN TEXTILE PLY**

5

Invention field

The present invention is included in the area of industrial control of the tyre manufacturing process.

10 **Previous Investigation**

The manufacture of tyres is the object of a very rigorous and demanding quality control that targets the guarantee of safety conditions since the physical integrity of people depends on their utilisation.

15 Under the present manufacturing conditions no tyre with any type of defect reaches the market since quality control is exhaustive, all tyres are tested, instead of statistical, by sample. This fact bears significant costs, since defects are not always detected at the initial manufacturing stages causing a significant waste of finished product.

20 One of the aspects that are identified as the originator of defects is the splice of the textile ply. A wrongly done splice consists of an overlap with a reduced or excessive number of cords or textile thread. A system that does the counting of this number of threads will enable the elimination of a significant number of defects and contribute towards a pronounced reduction of costs.

25 The present invention views the solving of this problem through an automatic control and monitoring system of the tolerance of splice overlap in textile ply, which enables the identification of the overlap area and counting of thread or cord fabric, and the generation of a control signal for the remaining manufacturing equipment.

30 **State of the technique**

The continuous monitoring of textile ply splices used in the tyre manufacturing is not referred to in any patent of the knowledge of inventors. The research carried out allowed some patents in the tyre manufacturing area to be identified, which are not concerned with the manufacturing stage within which the present invention is encompassed: EP 0 869 330 A2, *Apparatus for testing tyre tread depth*, where it is intended to determine the depth of the tyre's tread; US 4 892 609, *Automatic material feeder in tire forming machine*, which is encompassed by manufacturing and not by quality control; US 5 895 845, *Method and gauge for measuring the tread depth of a motor vehicle tire*, of a similar scope to EP 0 869 330 A2; US 3 997 783, *Method for testing the adhesion between the rubber compound and the cord fabric of a pneumatic tyre*, which refers to the quality control of the adhesion between thread or cord fabric and the rubber. Since this deals with the analysis of the characteristics of a continuous ply, research was carried out and some patents were found in this area, but they do not contemplate the relevant aspects of this invention. Therefore, the patents EP 0 366 235 A1, *Monitoring systems and methods*; EP 0 392 693 A2, *Online texture sensing*; US 5 256 883, *Method and system for broad area field inspection of a moving web, particularly a printed web*; EP 0 757 245, *Apparatus for detecting streaky surface defects*; NL 9 500 151, *Method and apparatus for inspecting a web of material for defects, using the method in preparing a magazine reel in a reel changer, and reel changer provided with such an apparatus*; US 4 277 178, *Web element concentration detection system*, refer to the analysis of the surface of plies, detection of elements, failures, textures, and not to the analysis in its thickness as is the case of the present invention. The patent EP 0 329 889 A2, *Method and apparatus for analysing a web of material*, generates the profile of thickness of a ply or similar, but differs from the present invention because the present one detects and counts elements, thread or cord fabric, instead of simply

detecting the occurrence of a different thickness. The patent US 4 842 413, *Apparatus for assessing the weld in belt layers for radial pneumatic tires*, analysis the alignment conditions of the surface of the metallic plies for radial pneumatic
5 tyres but once again the analysis does not refer to the thickness of the ply nor to the counting of the elements but to the alignment of layers.

In terms of commercial products, the inventors are unaware of the existence of any product that solves the problem the
10 present invention intends to solve. Bytewise, an American company, commercialises a product that enables the monitoring and measurement of the thickness of the overlap splice of textile ply in tyre manufacturing. Nevertheless, it does not count the threads and the information it supplies, thickness
15 of the overlap has little interest, once the quality of the product depends on the existence of an adequate number of cord fabric and not simply of the thickness of the splice. The contrary may occur, where the thickness is adequate but the overlap does not contain the adequate number of threads,
20 which is a source of defect in the final product. In these situations, the information of such a system may be incorrect or misleading.

Brief Description

25 The present invention is constituted by: a sub-system of image acquisition (2) containing the modules of lighting, artificial vision and respective elements of support, fixation, conditioning and adjustment (3); a computerised quality control program composed by a module of morphologic
30 analysis of image for the detection and recognition of overlap of fabric ply, detection and counting of threads or cords in the overlap area, a module of support to the decision process of acceptance/rejection of ply based on the parameters defined by the user and a module for interfacing
35 with production equipment.

Brief Description of the Drawings

Drawing 1 shows a typical example of an overlap splice of fabric ply used in tyre manufacturing.

5 Drawing 2 shows the configuration of the system in typical application scenario in the tyre industry.

Drawing 3 illustrates the sub-system of image acquisition.

10 Detailed Description

The manufacturing of a tyre takes place in different sequential phases: Mixing, Preparation, Building, Curing and Quality Control. In the Preparation phase, the different rubber compounds mixed in the previous phase, Mixing, are
15 used for the production of the components of the pneumatic tyre, amongst which is the textile ply.

This component has the function of guaranteeing the resistance of the tyre through the creation of conditions to contain the air introduced, guaranteeing the support of the
20 intended load. Basically, a roll of textile fabric composed of cords (1b, previously prepared is guided to the calender that will impregnate it with rubber (1c). This ply is later on cut at 90° to the direction of the cord, in a width foreseen for a certain tyre size. The various segments of the
25 ply are spliced overlapping a certain number of cords forming again a sole piece. The ply is rolled up for later usage.

In the calendering of textile fabric, two types of situations that cause imperfections in the overlap splices in the preparation phase of the textile ply, and consequently, cause
30 the non-approval of the tyres in the quality control test, may occur:

Excess rubber on the ends of the fabric - Whenever necessary, in the textile-cutting machine, the excess rubber on the ends of the fabric is removed. If this
35 operation is not done correctly, the overlap is not

perfect since in that area there will be, at least in one of the segments, rubber without cords.

Failure of cords - In some situations, when the ply reaches the textile cutter machine, the ply has some cord failures. In this situation there will also not be a perfect overlapping.

If in the textile cutter machine, the overlap splicing process is not correctly adjusted, it may cause splices with an excessive or reduced overlap space. In both cases, the splices will cause imperfections that will imply the non-approval of the tyre in the final quality control tests. A considerable part of the costs of the non-quality tyre production are consequence of these defective overlap splices of textile ply.

The present invention describes a system that enables the identification of the overlap area and the counting of textile cords fabric in that area and the generation of a control signal for the remaining manufacturing equipment. The identification of the overlap area and counting textile cords is done in both extremities of the overlap splice.

The textile ply (4), after being spliced, is placed on a conveyor belt to be rolled up (5) in coils. Upon passing through the openings 5a) and 5b) existent in the image acquisition module (2), the acquisition at a rate of 50 frames per second of the two images obtained in both extremities of the overlapping splice is done and are subsequently digitised and processed in real time. The sub-system of image acquisition (2) enables the creation of environmental lighting conditions and protection of the exterior atmosphere that guarantee constant levels of contrast and colour for the gathered images. In practice, these conditions were achieved by adequately positioning the sources of light and equipping the sub-system with conditions to mitigate the internal reflection: internal barriers of light obstruction in the form of partitions (6) duly positioned and diaphragms for incandescence interception,

painting with matt dark paint, bristle curtain or similar material on the ply circulation slots. This sub-system of image acquisition (2) may be constituted by lighting modules (7) of coherent or incoherent light, in the form of incandescent or fluorescent lamps, LED or laser, or others. With respect to the light characteristics it may be uniform, collimated or structured, with a fixed or sweeping beam, and its wavelength be in the area of visible light spectrum, infra-red or ultra-violet. It may still be stroboscopic, which will enable the synchronisation with the detection process on behalf of the module of artificial vision. Other intrinsic characteristics of light such as its polarisation may also be used. The positioning of sources of light in relation to the ply circulation slot was another issue that was explored and used. This diversity views to mitigate the problems of internal reflection in the casing of the image acquisition module as well as facilitating the identification of the overlap area and of the cords in that area by the computerised quality control program.

The cameras (8) are of CCD type, colour and equipped with an optic system that enables an adequate zoom.

The system of support, fixation and adjustment of the image acquisition module (3) was done by a worm screw controlled by an engine (9) that positions the cameras (9) on both extremities of the ply in a symmetrical way.

The acquired images are transferred to a computer, where the quality control program, in the morphologic analysis module, realises the operations of splice detection and, in its presence, effectuates the counting of the number of cords existent in the overlap.

Upon analysing the profile of the textile ply on the overlap splice area, for this effect, only the splice area where there is overlapping of cords is considered. That is, on a splice where there is excess rubber on the ends of the fabric, both on the superior and inferior part, this overlap space shall not be considered as a splice. This means that a

splice must be considered as good or bad, depending on the number of cords only on the overlap area.

According to the specification of the manufacturing process, the stoppage of the splice system is undertaken when the
5 number of cords is beyond the pre-established tolerance limits, through a computer program that supports the decision of acceptance/rejection of the ply, in communication with an interconnection program with the remaining productive equipment, usually done through a programmable logic
10 controller, PLC. The quality control program is sufficiently versatile to enable a great diversity of stoppage criteria, both at individual splices as well as of sequences of splice failures, so as to optimise the quality control process in view of the specific production equipment and of its
15 manufacturing process.

CLAIMS

- 1) An automatic control and monitoring system for splice
5 overlapping tolerance in textile ply, characterised by
being composed of:
- a) Sub-system of image acquisition (2) containing the
modules of lighting, artificial vision and respective
support, fixing, conditioning and adjustment (3)
10 elements;
 - b) Quality control computer program comprised of the
following modules:
 - c) Morphological analysis of image for the detection and
recognition of the overlapping of textile ply, detection
15 and counting of threads or cords in the overlap area;
 - d) Support to the decision making process of
acceptance/rejection of the ply based on the parameters
defined by the user;
 - e) Interconnection with production equipment.
- 20 2) An automatic control and monitoring system for splice
overlapping tolerance in textile ply according to claim 1,
characterised by the lighting module being comprised of:
- a) A source of light (7), coherent or incoherent;
 - b) A casing to hinder the entrance of ambient light;
 - 25 c) A background surface (10) to originate an adequate
contrast for the functions of identifying the
overlapping region and counting of cords.
- 3) An automatic control and monitoring system for splice
overlapping tolerance in textile ply according to claim 1,
30 characterised by the fact that the lighting module has a
uniform source of light or radiation.
- 4) An automatic control and monitoring system for splice
overlapping tolerance in textile ply according to claim 1,
characterised by the fact that the lighting module is
35 constituted by a fixed or a sweeping beam.

5) An automatic control and monitoring system for splice overlapping tolerance in textile ply according to claim 1, characterised by the fact that the lighting module is of collimated light.

5 6) An automatic control and monitoring system for splice overlapping tolerance in textile ply according to claim 1, characterised by the fact that the lighting module is of structured light.

10 7) An automatic control and monitoring system for splice overlapping tolerance in textile ply according to claim 1, characterised by the fact that the lighting module is of visible, infra-red or ultra-violet light.

15 8) An automatic control and monitoring system for splice overlapping tolerance in textile ply according to claim 1, characterised by the fact that the lighting module is of stroboscopic light.

20 9) An automatic control and monitoring system for splice overlapping tolerance in textile ply according to claim 1, characterised by the fact that the lighting module is of polarised light.

10) An automatic control and monitoring system for splice overlapping tolerance in textile ply according to claim 1, characterised by the fact that the lighting module is comprised of incandescent lamps, fluorescent lamps, -25- halogen lamps, lasers in solid state, gaseous lasers, laser diodes or light emitting diodes (LED).

11) An automatic control and monitoring system for splice overlapping tolerance in textile ply according to claim 1, characterised by the fact that the lighting module has one 30 or more sources of light or radiation positioned frontally to the textile ply or at an angle between -90° and $+90^{\circ}$.

12) An automatic control and monitoring system for splice overlapping tolerance in textile ply according to claim 1, characterised by the fact that the casing that hinders the 35 entrance of ambient light has a set of partitions (6) duly

positioned to diminish the reflection of light lost in the walls of the referred casing.

13) An automatic control and monitoring system for splice overlapping tolerance in textile ply according to claim 1, characterised by the fact that the casing that hinders the entrance of ambient light has diaphragms for the interception of incandescence.

14) An automatic control and monitoring system for splice overlapping tolerance in textile ply according to claim 1, characterised by the fact that the casing that hinders the entrance of ambient light has, in the ply circulation slot, an external light barrier in the form of curtains or bristle bars or any other similar material.

15) An automatic control and monitoring system for splice overlapping tolerance in textile ply according to claim 1, characterised by the fact that the background surface (10) is inclined at an appropriate angle, depending on the visual field of the referred camera, to diminish the retro-reflection of the referred background surface onto the mentioned camera.

16) An automatic control and monitoring system for splice overlapping tolerance in textile ply according to claim 1, characterised for having a device for the detection of the thickness of the textile ply, either mechanic, electronic, optoelectric or another type, which enables to synchronise the release of the shutters of the video cameras with the passage of the overlapping splice region.

17) An automatic control and monitoring system for splice overlapping tolerance in textile ply according to claim 1, characterised by the fact that the background surface has on the inner surface in the area of the ply circulation slot one or more marks that limit the observation area facilitating its identification by the computerised morphologic analysis program.

18) An automatic control and monitoring system for splice overlapping tolerance in textile ply according to claim 1,

characterised by the fact that the module of artificial vision has a video camera or cameras (8) of the type CCD, with the following characteristics:

- a) interline transfer, frame, complete frame or other architecture;
- b) arrangement of points with in line or on area sweeping;
- c) spectrum of sensibility to one colour or to various colours in the visible, in the infra-red or ultra-violet spectrum.

19) An automatic control and monitoring system for splice overlapping tolerance in textile ply according to claim 1, characterised by the fact that the module of artificial vision has a camera or cameras that function in synchrony with the lighting system of stroboscopic light.

20) An automatic control and monitoring system for splice overlapping tolerance in textile ply according to claim 1, characterised by the fact that the module of artificial vision has a camera or cameras with polarising filters.

21) An automatic control and monitoring system for splice overlapping tolerance in textile ply according to claim 1, characterised by the fact that the support, fixation and adjustment element of the image acquisition module is comprised of a mechanical assembly of an worm screw or other, manually activated or by an motor (9) controlled by the operator, or automatically.

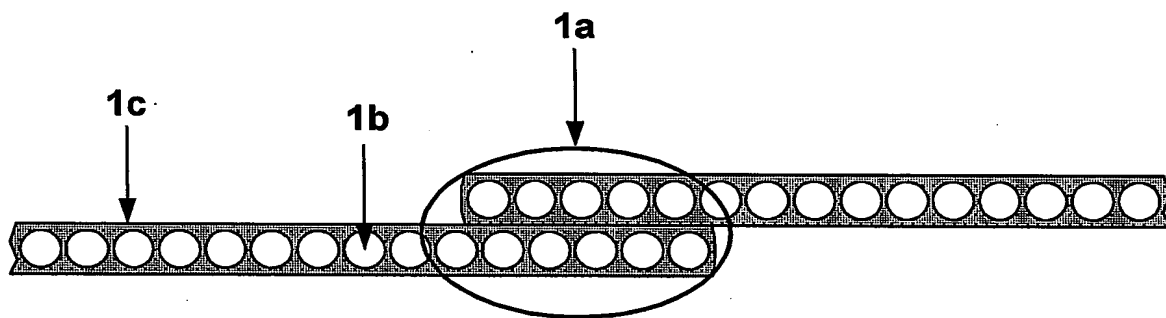
22) An automatic control and monitoring system for splice overlapping tolerance in textile ply according to claim 1, characterised by the fact that the quality control computer program has a morphological module of image analysis that enables the:

- a) Detection and recognition of the overlapping of the textile ply;
- b) Detection and counting of cords in the overlap area;
- c) Adjustment of detection in view of the colours and dimension of the ply, of the cords and of the rubber, by the operator or automatically.

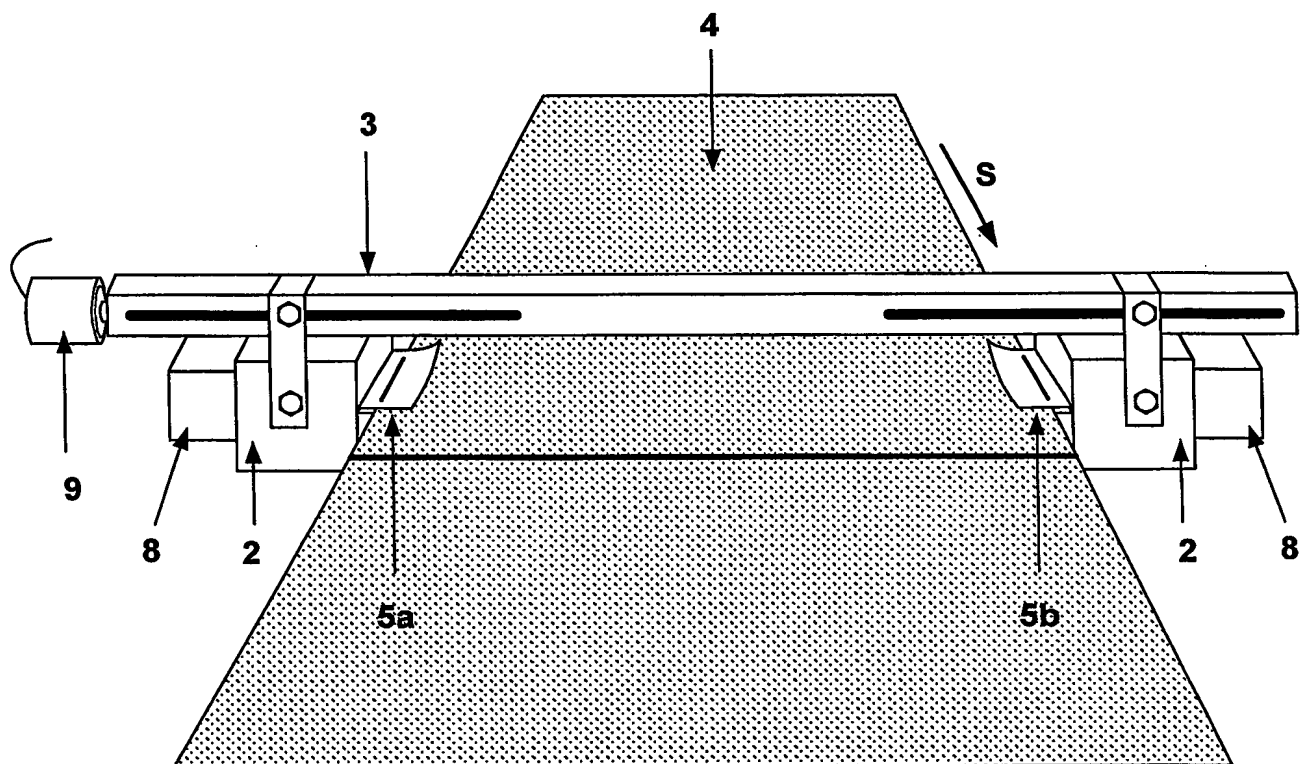
23) An automatic control and monitoring system for splice overlapping tolerance in textile ply according to claim 1, characterised by the fact that the quality control program has a decision module of acceptance/rejection of the ply that enables the user to define the parameters and criteria, as for example, the maximum and minimum number of faults or patterns of the ply batches with certain sequences of faults.

24) An automatic control and monitoring system for splice overlapping tolerance in textile ply according to claim 1, characterised by the fact that the quality control program has an interface module with the remaining production equipment that enables the interface with a programmable logic controller, PLC.

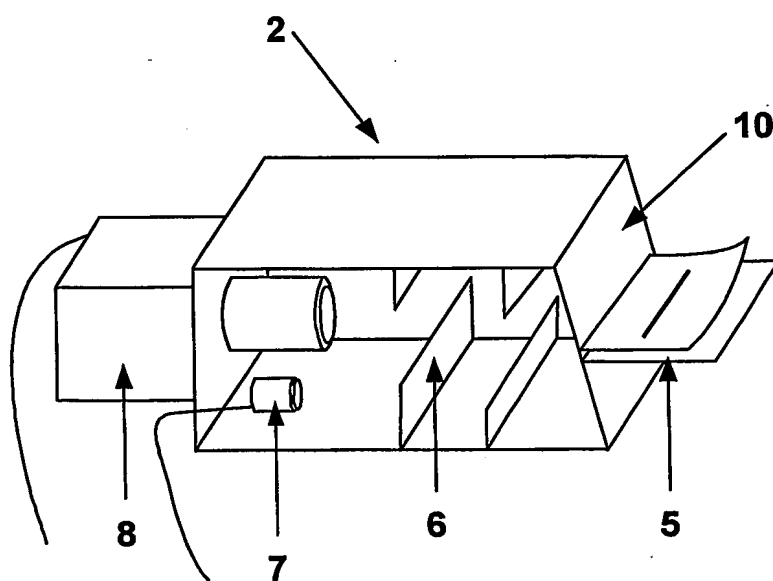
25) Utilisation of the automatic control and monitoring system for overlapping splice tolerance in textile ply according to the claims 1 to 24, in the tyre production industry.



F I G. 1



F I G . 2



F I G . 3

INTERNATIONAL SEARCH REPORT

International

Application No

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A. CLASSIFICATION OF SUBJECT MATTER

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Minimum documentation searched (classification system followed by classification symbols)

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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the International search (name of data base and, where practical, search terms used)

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	PATENT ABSTRACTS OF JAPAN vol. 008, no. 143 (M-306), 4 July 1984 (1984-07-04) -& JP 59 039538 A (YOKOHAMA GOMU KK), 3 March 1984 (1984-03-03) abstract; figures	1
A	PATENT ABSTRACTS OF JAPAN vol. 015, no. 107 (P-1179), 14 March 1991 (1991-03-14) -& JP 03 002511 A (BRIDGESTONE CORP), 8 January 1991 (1991-01-08) abstract; figures	1
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Information on patent family members

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